FIG. 2A illustrates a power spectral density function at a base station's receiver/transmitter antenna due to one wireless device transmitting data without spreading;

FIG. 2B illustrates a power spectral density function at a base station's receiver/transmitter antenna due to another wireless device transmitting data without spreading;

FIG. 2C illustrates a composite power spectral density function and a partial power spectral density function at a base station's receiver/transmitter antenna due to transmission by two wireless devices after spreading;

FIG. 2D illustrates conceptually a composite power spectral density function at a base station after partial despreading using a code for one wireless device;

FIG. 2E illustrates conceptually a composite power spectral density function at a base station after partial despreading using a code for another wireless device;

FIG. 3 illustrates a composite power spectral density function and a partial power spectral density function at a base station's receiver/transmitter antenna due to transmission by two wireless devices after spreading and power control in accordance with the present invention;

FIG. 4 illustrates a composite power spectral density function and a partial power spectral density function at a base station's receiver/transmitter antenna due to transmission by two wireless devices after spreading and power control in accordance with the present invention where the wireless devices have differing quality of service requirements;

FIG. 5 is a schematic of a base station which controls the power transmitted by wireless devices in accordance with the present invention;

FIG. 6 is a flow chart of a method for controlling the power transmitted by wireless devices;

FIG. 7 is a schematic of a base station which controls the power transmitted by wireless devices and generates probability and/or load and population data for transmission to wireless devices;

FIG. 8 is a schematic of a wireless device which uses probability values or load and population data values to control transmission of data;

FIG. 9 is a flow chart for determining equivalent current load values;

FIG. 10 is a flow chart for determining equivalent population values; and

FIG. 11 is a flow chart for transmitting equivalent current load and equivalent population values or probability of transmission values to a wireless device.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a simple illustration of two wireless devices 12 and 14 and a base station 22. The wireless devices 12 and 14 include receiver/transmitter antennas 16 and 18 respectively. Base station 22 includes a receiver/transmitter antenna 20. FIG. 1 will be used in conjunction with FIGS. 2A–2E to describe known techniques for transmission and reception of power from wireless devices with CDMA spreading and without CDMA spreading. Details of a base station and wireless device in accordance with the present invention will be described later.

The wireless devices 12 and 14 transmit access request signals via receiver/transmitter antennas 16 and 18, respectively, and the access request signals are received by the receiver/transmitter antenna 20 of the base station 22. If both wireless devices 12 and 14 are given access to an uplink frequency channel of the base station 22 then wireless devices 12 and 14 transmit data signals to the base station 22.

FIGS. 2A–2E show power spectral density functions at the receiver/transmitter antenna 20 of the base station 22 of FIG. 1. Power spectral density P(ω), is shown graphed on the y-axis and frequency in radians, ω, is shown graphed on the x-axis.

FIG. 2A illustrates the power spectral density function 24 at the receiver/transmitter antenna 20 of FIG. 1 due to data transmission by the wireless device 12 when spreading is not used. The power spectral density function 24 of FIG. 2A has a power spectral density $P(\omega)-P_A$ at frequencies in the bandwidth $\omega_c \pm (R_1/2)$, where ω_c is the carrier frequency and R_1 is the data rate of the wireless device 12. The power received from wireless device 12 at receiver/transmitter antenna 20 equals P_A times the data rate R_1.

Similarly, FIG. 2B illustrates the power spectral density function 26 at the receiver/transmitter antenna 20 of the base station 22 of FIG. 1 due to the wireless device 14 when spreading is not used. The power spectral density function 26 of FIG. 2B has a power spectral density $P(\omega)-P_A/2$ at frequencies in the bandwidth $\omega_c \pm (R_2/2)$, where ω_c is the carrier frequency and R_2 is the data rate of the wireless device 14 of FIG. 1. The power received equals $P_A/2$ times the data rate R_2. In this instance the data rate of wireless device 14, which is R_2, is twice the data rate of wireless device 12, which is R_1.

FIG. 2C illustrates a composite power spectral density function 28 at the base station receiver/transmitter 20 due to wireless devices 12 and 14 both transmitting data signals at a spreading rate of R_3. FIG. 2C further illustrates a partial power spectral density function 30 at the receiver/transmitter 20 of base station 22 due to the wireless device 12 transmitting a data signal at the spreading rate of R_3, where $R_3=2R_2=4R_1$. The composite power spectral density function 28 of FIG. 2C comprises the partial power spectral density function 30 due to the wireless device 12, which has power spectral density $P(\omega)=P_A/4$ at frequencies in the bandwidth $\omega_c \pm R_3/2$, where ω_c is the carrier frequency and R_3 the spreading bandwidth. The total power received at receiver/transmitter 20 equals $P_A/2$ times the spreading bandwidth R_3. The composite power spectral density function 28 of FIG. 2C further comprises the partial power spectral density function due to the wireless device 14, which has a power spectral density $P(\omega)=P_A/2-(P_A/4)=(P_A/4)$ at frequencies in the bandwidth $\omega_c \pm (R_3/2)$. The power spectral density functions due to each wireless device are added together to form the composite power spectral density function 28 in FIG. 2C. The composite power spectral density function 28 has power spectral density $P(\omega)=P_A/2$ at frequencies in the bandwidth $\omega_c \pm (R_3/2)$.

The spreading operation takes place inside each wireless device and causes all signals to be spread over the same bandwidth or spreading rate, R_3. The bandwidth of the signal transmitted from the wireless device 12 is spread to four times its data rate and the bandwidth of the signal transmitted from the wireless device 14 is spread to two times its data rate. Typically, when CDXA spreading is used, the majority of wireless devices will have their data signals spread over a much larger bandwidth. The spreading factor F of the base station is the spreading bandwidth divided by a minimum reference data rate. In this case, $F=R_3/R_1=4$.

After spreading, each signal is transmitted from its respective wireless device. The composite spread signal ("CS"),